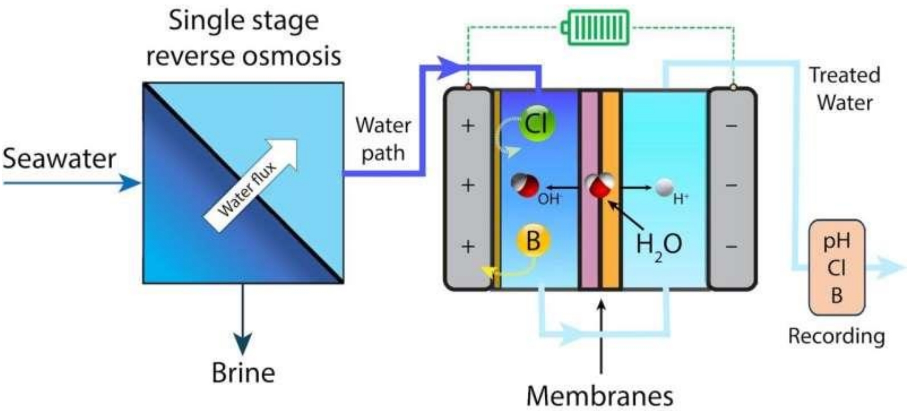
New water purification technology helps turn seawater into drinking water

Water desalination plants could replace expensive chemicals with new carbon cloth electrodes that remove boron from seawater, an important step of turning seawater into safe drinking water. Given that global desalination capacity totalled 95 million cubic meters per day in 2019, the new membranes could save around $6.9 billion annually. Those kinds of savings could help make seawater a more accessible source of drinking water and alleviate the growing water crisis. Freshwater supplies are expected to meet 40% of demand by 2030, according to a 2023 report from the Global Commission on the Economics of Water.

Boron is a natural component of seawater that becomes a toxic contaminant in drinking water when it sneaks through conventional filters for removing salts.
Seawater's boron levels are around twice as high as the World Health Organization's most lenient limits for safe drinking water, and five to 12 times higher than the tolerance of many agricultural plants.

In seawater, boron exists as electrically neutral boric acid, so it passes through reverse osmosis membranes that typically remove salt by repelling electrically charged atoms and molecules called ions. To get around this problem, desalination plants normally add a base to their treated water, which causes boric acid to become negatively charged. Another stage of reverse osmosis removes the newly charged boron, and the base is neutralized afterward by adding acid. Those extra treatment steps can be costly.



This diagram shows how boron is removed by the researchers' electrodes. First a majority of the salt ions are removed with reverse osmosis. Then the water flows into a cell containing a membrane with positive (pink) and negative (orange) layers. Similarly charged electrodes face the membrane layers, and when a current is applied, water molecules at the interface of the membranes split into hydrogen and hydroxide ions. The hydroxide ions stick to boron, causing it to stick to the positive electrode. Credit: Jovan Kamcev, Kamcev Research Lab, University of Michigan, and Weiyi Pan, Elimelech Research Lab, Rice University.
The new electrodes remove boron by trapping it inside pores studded with oxygen-containing structures. These structures specifically bind with boron while letting other ions in seawater pass through, maximizing the amount of boron they can capture.

But the boron-catching structures still need the boron to have a negative charge. Instead of adding a base, the charge is created by splitting water between two electrodes, creating positive hydrogen ions and negative hydroxide ions. The hydroxide attaches to boron, giving it a negative charge that makes it stick to the capture sites inside the pores in the positive electrode.

Capturing boron with the electrodes also enables treatment plants to avoid spending more energy on another stage of reverse osmosis. Afterward, the hydrogen and hydroxide ions recombine to yield neutral, boron-free water. (Source: Nature Water 2025).

Jovan Kamcev, an assistant professor of chemical engineering and macromolecular science and engineering at U-M, places a filter membrane between two electrodes, which measure how well the membrane conducts electricity. This helps his team predict how well it can purify water. Credit: Marcin Szczepanski, Michigan Engineering.